to press upon the right half of the cerebellum, which it had to some extent excavated. This mass was enclosed in a sheath of pia mater continuous with that over the posterior part of the right cerebral hemisphere. Dr. Wilson thought that the spherical mass might at one time have been joined to the cerebral hemisphere, but of this there was no direct evidence. Microscopically the tumour mass contains true nerve-cells, and so is an example of an extremely rare condition.

3. On a peculiarly Abnormal Specimen of Turbot.

By J. T. Cunningham, M.A., F.Z.S.

[Received January 23, 1907.]

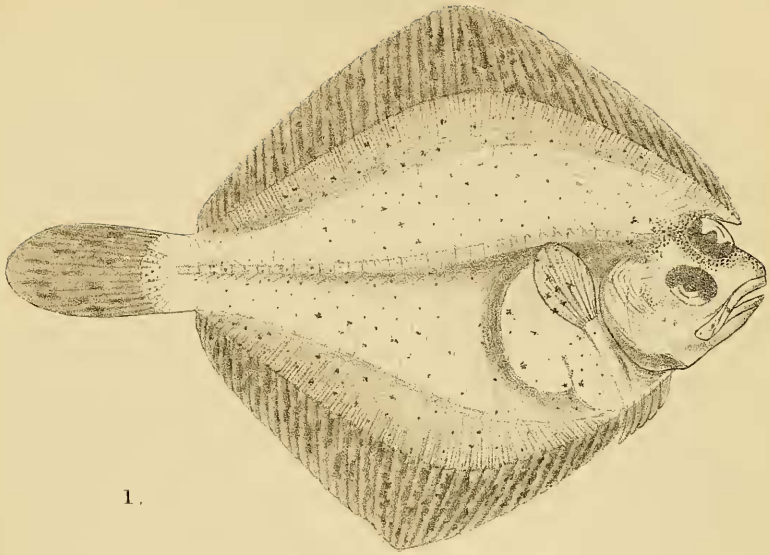
(Plate XI.*)

The specimen here described was sent to me by Dr. E. J. Allen, Director of the Marine Biological Laboratory, Plymouth, in the beginning of December 1906, with a request that I should examine and describe it. With the fish was a normal specimen and two letters referring to them—one from Mr. John D. Enys, the other from Miss Olivia L. Fox. Mr. Enys' letter is dated Nov. 3, 1906, and states that Miss Fox had then alive in a glass globe two small Turbot caught on the sands at Polzeth, near the Doom Bar at Padstow, on the north coast of Cornwall; that the abnormal fish was dark on the under side and white on the upper. Miss Fox's letter states that she had had the fish about a month, and that the upper side "was becoming pigmented" since she first obtained it.

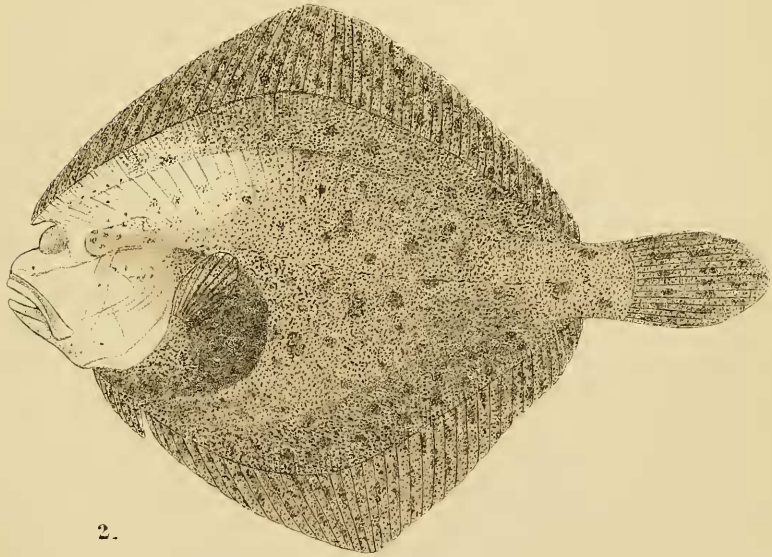
The specimen is 4·4 cm. in length and presents a condition which, so far as I am aware, has never previously been observed or described in flat-fish of any species. With respect to the position of the eyes, the fish is a reversed specimen—that is to say, both eyes are on the right side, whereas normally in Turbot they are on the left. With respect to colour, on the contrary the specimen partially resembles a normal Turbot. The right side is almost entirely unpigmented; the greater part of the left side is coloured like a normal Turbot. The pigmentation does not extend uniformly over the whole of the left side, but is absent from the head, and from the anterior part of the dorsal region above the head. On these areas there are only a few scattered black chromatophores. On the right or uncoloured side there are also scattered black chromatophores rather more numerous than on the left side of the head. It is important to note that the head and anterior region of the right side, although not fully pigmented, have more pigment than the rest of that side; between the eyes and around the dorsal eye pigmentation is almost complete.

The number of dorsal fin-rays in the specimen is 65, of the ventral 47. The characteristic tubercles of the adult Turbot are not yet developed, but there are three little projections at the base of each of the dorsal and ventral fin-rays, and also projections

* For explanation of the Plate, see p. 181.



1.



2.

J. T. C. del.

J. Green lith.

ABNORMAL YOUNG TURBOT.

at the bases of the caudal and ventral rays. These are probably the beginnings of marginal tubercles.

The anterior end of the dorsal fin and the basal tissue which carries it form a projecting hook-like process over the dorsal eye—that is, the originally left eye, which has moved to the right side of the head. This projection, due to the absence of attachment between the base of the fin at the anterior end and the head, occurs commonly in ambicolorate specimens of the turbot and less frequently in ambicolorate specimens of other species of *Pleuronectidæ* (see Cunningham and MacMunn, "Coloration of Skins of Fishes, &c.," Phil. Trans. 1894).

A letter from Miss Fox to Dr. Allen, dated Jan. 7, 1907, explains that the fish was caught on Sept. 28 last year, and lived in captivity till Nov. 28, when it died from some unknown cause. When caught it was, unlike all the others seen at the same time, quite stationary on the sand, which Miss Fox thought might imply a certain blindness. In captivity, however, it was very active, and certainly saw food very quickly, so that there is no reason to think the function of the eyes was affected.

In Plate XI. I have figured the two sides of the abnormal specimen. The normal specimen was 4·2 cm. long. Its metamorphosis is complete, but there are still a few scattered black chromatophores on the right or lower side. Similar black chromatophores are present on the right side of the abnormal specimen, and they appear to be larger and slightly more numerous; but the difference is slight, so that the exposure of the right side to light during the two months it was in captivity had not produced much effect.

It seems to me that the only way to attempt an explanation of the condition of this specimen is to base the explanation on the view of the constitution of the ovum which was developed by Weismann, and which is adopted in the Mendelian doctrine of heredity. If the right side of the anterior or cephalic region were more completely pigmented, we might regard the fish as consisting of an anterior smaller part which was reversed, and a posterior part which was normal. The condition would then be explained by supposing the specimen developed from an ovum consisting of parts usually occurring in separate ova. We know that reversed specimens occur in various species of flat-fishes, *e. g.* the Flounder (*Pleuronectes flesus*). In this species in some localities reversed specimens are not only common, but abundant. At Plymouth I found about 30 per cent. of the specimens captured had the eyes and pigment on the left side instead of on the right. It is necessary here to consider the precise terms to be used to indicate the structural peculiarities which present themselves. It has been usual to speak of a Flounder with eyes on the left side as reversed; but if we use the substantive corresponding to this adjective, namely reversion, we are using a term which has been employed in an entirely different sense, namely as meaning atavism, or the recurrence in a species of some more or less remote ancestral form.

It is true we might use the word reversal, but this is not sufficiently distinct. In order to avoid confusion it will be better to coin a new term, and it seems to me the most appropriate term is "metastrophe," meaning a change in the direction of the turning. For adjectives we may use merely sinistral or dextral, referring to left or right side, or for the abnormal condition in general we may use metastrophic.

Since, then, metastrophe frequently occurs in flat-fishes, and is a congenital abnormality due to some abnormality in the constitution of the ovum, it is intelligible that it should occur in one part of a fish and not in another. We may suppose the abnormality in the whole fish is due to the interchange of position in the ovum of the parts corresponding to the left and right sides of the body. The abnormality does not, however, affect the viscera, which, as I have pointed out in the memoir already cited, are constant in position whether the fish is dextral or sinistral. In the particular specimen of Turbot which we are considering, the head is dextral, or metastrophic, the posterior portion normally sinistral, and its origin is to be attributed to a corresponding abnormality in the constitution of the ovum from which the fish was developed.

With regard to the question of the origin of such abnormalities in the ovum, they may arise either in the cell-divisions which occur in the multiplication of ova or spermatozoa of gametes, to use the general term, or in the process of fertilisation, the conjugation of the gametes. It might be suggested in this particular case that the condition was due to a "cross" between an abnormal dextral specimen and a normal sinistral specimen, the condition of the head-region being inherited from one parent and that of the posterior region from another. But metastrophic or dextral specimens are, so far as my experience goes, rare in the Turbot, and it seems equally possible that the peculiar condition of the gamete which gave rise to the abnormality was not due to the condition of one of the parents.

It is not necessary to suppose that both of the gametes which produced the fertilised ovum were abnormal: abnormality in one only may have been sufficient to produce the abnormality of development. In the division of the gametes within the reproductive organ of a parent fish, the chromosomes of the nucleus, which are supposed to be the "carriers of heredity" or to contain the "determinants" which produce the characters of the organism to which the gamete gives rise, normally divide severally so that two similar ova are produced. In the final or reduction division each chromosome does not divide, but the group of chromosomes separates into two groups. In one or other of these divisions the determinants might be displaced, so that either all or some of those belonging to the left side were on the right and *vice versâ*, and thus a metastrophic gamete would be produced.

One important question that arises from the condition observed in the specimen under discussion is, what bearing it has on the experiments carried out by me some years ago at the Plymouth

Laboratory, and described in the paper already cited. In those experiments pigment was developed on the lower sides of Flounders as a result of the incidence of light. Here we have a specimen of Turbot in which the upper side is exposed to light and is not pigmented, while the lower side is pigmented. But it must be noted that no adult specimen has been observed in which this condition occurs. According to Miss Fox's letter quoted above, the upper side of this young turbot had already acquired some pigment during the two months in which it lived in her possession. It is quite possible therefore that if the specimen had lived to become adult, the upper or right side would have become fully pigmented in consequence of the action of light, and then the specimen would have been exactly similar to other ambicolorate specimens of Turbot, except that it was metastrophic, the eyes being on the right side instead of the left.

In my experiments, I showed that when young fish in process of metamorphosis were placed in the apparatus so that light fell on the lower side and not on the upper, the normal hereditary changes were not arrested, pigment disappeared from the lower side as under normal conditions, and it was only later, after long exposure to light, that pigment was developed on the lower side. Thus, as the specimen we are here considering had not long passed its metamorphosis, there is nothing inconsistent with my results in the absence of pigment from the right side, although that side is uppermost and had been exposed to light for a short time.

The condition of the specimen here described suggests that the usual ambicolorate abnormality is due also to partial metastrophe, but that in these cases the *anterior* part of the body is normal or sinistral, and the *posterior* part dextral. This view would explain the remarkable fact, of which hitherto no explanation has been given, that in the great majority of ambicolorate Turbot the lower or right side of the head is unpigmented, just as in the specimen here described the left side of the head is unpigmented. The limits of the pigmentation are not absolutely constant. In the majority of specimens which I have seen, the pigmentation extends on to the lower jaw and the anterior end of the dorsal fin, while the rest of the head in front of the preopercular bone is unpigmented. One specimen in my list, however, had pigmentation over the whole of the lower side, including the head. If the explanation suggested is correct, it follows that the young of an ambicolorate specimen immediately after metamorphosis is without pigment on the postcephalic portion of the upper or left side, and that it becomes ambicolorate in adult life in consequence of the development of pigment on that side under the influence of light. There is at present no direct evidence of this beyond the occurrence of the specimen described in this paper, and the question must be further investigated by the examination of large numbers of young specimens. When pigmentation extends over the whole of the lower side, including the head, it cannot be said that the head of the fish is normally asymmetrical; therefore the theory of

partial metastrophe does not apply. In this case we must conclude that some other explanation is to be sought, or we may suppose that the boundaries between the determinant groups in the ovum are not definite, and that the pigment determinants displaced to the right side have extended to the head-region.

It may be objected that the persistence of colour on the lower side of an ambicolorate Turbot is inconsistent with my views of the action of light, that if pigment were produced on the upper side it ought to disappear from the side turned to the ground. This objection is of little weight, for my experiments show that it is easier by means of light to produce some pigment where it was previously absent, than to abolish it when it is present, by cutting off the light. This is what might be expected, for in the evolution of a flat-fish pigment has only recently disappeared from the lower side, in consequence, as I believe, of the absence of light; and therefore the pigmentless condition is not very strongly inherited, and pigment is produced after a comparatively short exposure to light. The positive character on the other hand, the presence of pigment, has existed not only since the flat-fish was evolved, but in a long line of ancestors before that, and therefore it would probably take several generations to cause the pigment to disappear completely by cutting off the light. It is quite possible that when the lower side is congenitally pigmented, some proportion of the pigment is lost in consequence of the absence of light, but such a loss would not be obvious to observation and would be difficult to demonstrate. Obviously a small amount of pigment appearing where there was none before is evident at once, but the disappearance of a small proportion from a strongly pigmented surface makes no apparent difference to the colour, and there is no means of measuring the amount of pigment for comparison in different cases. There can be no doubt concerning the presence of a single sheep in a field, but it is much more difficult to decide whether there are a thousand or 999 in a flock.

It has long been known that in *Pleuronectidæ* generally, and especially in *Rhombus maximus*, there is a marked correlation between ambicoloration and the malformation of the dorsal fin which occurs in the specimen described in this paper. It seems to be generally supposed that in such specimens the dislocated eye has not completed its change of position, and being on the edge of the head instead of on the upper side, prevents the usual growth forwards of the base of the dorsal fin. The condition is regarded then as, like the ambicoloration, a reversion on the part of the eyes and skull towards the primitive symmetry. Although I have not fully investigated the structure anatomically, it is my opinion, from external observation, that the eyes and skull are normal and that the peculiarity is merely due to a want of that attachment which normally occurs between the base of the fin and the skull, along the united ectethmoid or prefrontal, and frontal bones. The view I have suggested seems to me to give a better explanation of this abnormality than has hitherto been proposed. If the head

is metastrophic and the posterior region normal, as in the specimen here described, or *vice versâ*, as in ambicolorate specimens previously described, then the normal relation of the determinants of these parts in the ovum, and therefore in development, is wanting. The anterior end of the dorsal fin belongs to the posterior of the two portions abnormally joined in the fish. It tends to grow forward, but in the normal case in doing so unites with the right side of the skull (in the Turbot); whereas in the abnormal specimen here described, where the head is metastrophic, it has the left side of the skull opposite to it, and with this side it has no congenital relations, and so remains separate from it. In the more usual case, where the eyes are on the left side as usual but the fish is ambicolorate, a similar explanation would apply. Here the right side of the skull is opposite the fin, as in the normal fish; but the fin being itself metastrophic, the normal relations between fin and skull in development are disturbed, and consequently they remain separate. It may be said in fact that in all these cases the fish, or the ovum from which it develops, is composed of two separate parts united in an abnormal relation to one another in a plane transverse to the long axis of the fish. Consequently the normal continuity between the head and body is, as it were, imperfect; and in all probability this is the real reason why in these cases the anterior end of the dorsal fin remains unattached to the head.

The abnormality of the dorsal fin does not occur in specimens which are entirely metastrophic. Here, although the characters of the right side develop on the left, and *vice versâ*—that is to say, the determinants of the right and left sides have changed places—the dislocation of determinants in the gamete has taken place along the median plane, and therefore the longitudinal continuity between fin and skull is not disturbed.

It is important to mention that the abnormality of the fin in the specimen here described is not merely due to incomplete metamorphosis. The normal specimen of the same size, or rather smaller, sent with the abnormal, and captured at the same time, shows complete metamorphosis, and in it the dorsal fin extends forward attached to the head to a point anterior to the eyes.

The correlation between ambicoloration and the abnormality of the dorsal fin is not invariable. Cases occur in which ambicolorate specimens are in this respect structurally normal. In the Phil. Trans. memoir by myself and Dr. MacMunn (referred to above, p. 175), I made the generalisation from the specimens of Turbot then known to me, that if pigment was present over the whole of the body behind the pre-opercular bone, and also on the lower jaw and the anterior end of the dorsal fin, the malformation of the dorsal fin was present; whereas if the pigment was less than this, the malformation was absent. On the hypothesis of the cause which I have suggested, the absence of the malformation in the latter case is intelligible, for then the junction between the metastrophic and the normal parts of the body may be supposed to occur not between